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by

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The Inhalation Method of Ventilatory Scintigraphy of Lungs With Colloidal Indium

Maria Granowska, Zygmunt Ajewski, Wieslaw Graban

Scintigraphic examinations for evaluating the state of pulmonary circulation are well-known and commonly used (7, 8). The methods of scintigraphic examinations for evaluating pulmonary ventilation by inhalation have just reached the point where they are acquiring wider and wider popularity (1, 2). The majority of this type of research involves the use of radioactive gases such as Xe^{133} (3). The attractiveness of the inhalation method with gases is unfortunately reduced in our circumstances by a lack of proper equipment, namely a gamma camera and a data processing system interfaced with it, which are still rarities. Hence, there has been a continuing need to find an examination method which would permit utilization of the inhalation method based on the linear scintigraph. As a result of work on these problems in the Department of Radioisotopes at the Medical Academy's Institute of Radiology in Warszaw, in collaboration with the Medical Academy's I Clinic of

Internal Diseases in Warszaw, a method of inhalatory ventilatory lung scintigraphy has been developed and introduced to clinical examinations, based on a typical linear scintigraph (type PHODOT II of the firm Nuclear Chicago). The radioactive isotope is Ind^{113m}, whose physical properties permit its use in clinical examinations.

The first part of the examination comprises two stages: preparation of a colloid, and creation of an aerosol from the colloid; the aerosol is given to the patient for inhalation. The preparation of the colloid in the form of colloidal indium sulphide is accomplished with the method described by Szymendera J. (9). It consists in the creation of colloidal rhenium sulphide tagged with Ind^{113m}, which is formed in the reaction of potassium perrhenate with sodium thiosulphate in an acid medium. The preparation is stabilized with polyvinylpyrrolidone (PVP,molecular mass 10000) and brought by a phosphate buffer to the appropriate pH (5.6 - 6.0).

Radioactive indium is obtained from a sterile generator containing tin 113 adsorbed by an ion-exchanger. The attested activity of tin 113 is 10 mCi. Ind 113m is elutriated from a column with the aid of an elutriating agent provided with the generator (produced by The Radiochemical Center "Amersham" England). The following ingredients are used in producing the colloid: 4 ml of eluate from the generator, replenished by a physiological salt solution, if necessary; 2 ml of a solution of potassium perrhenate ($KReO_4$) and sodium thiosulphate ($Na_2S_2O_3$); .5 ml of .3 N hydrochloric acid solution; 2.5 ml of buffering solution (KH_2PO_4 and Na_2HPO_4) stabi-

lized with polyvinylpyrrolidone. The procedure, which lasts about 15 minutes, produces an isotonic, sterile, apyretic colloid tagged with Ind 113m, and with a volume of 9 ml and an activity of 5 mCi. Colloid efficiency is estimated at 99%, and particle diameter is .5-2 μm. The most important stage in preparing the inhalation examination is obtaining the necessary properties in the administered aerosol. Too great a particle diameter leads to precipitation in the aerosol in the upper respiratory passages. The proper spray, *i. e.*, an aerosol with a particle diameter less than 3 μm, can be obtained with an ultrasonic nebulizer.

A nebulizer from the firm LKB Sweden, model NB 108, is currently in use and has the following parameters: effective capacity .02-1.4 g/min, controlled flow within 2-20 *l*/min, control of humidification within 4-120%, operating frequency of ultrasonic generator 3 MHz, diameter of aerosol particles obtained less than 3 μm. It should be noted that in the production of the aerosol the proportional spread of the particle diameters is of fundamental importance, because the volume of a particle is proportional to the cube of its diameter. Thus the volume of a given particle with a diameter twice as large as the diameter of another particle is as much as eight times greater than the volume of the latter particle. On account of this, it would appear that a slight disparity in diameters can cause the greater part of the isotope to be found in the larger particles, which are not able to penetrate the lungs deeply enough. This is why the nebulizers in use are characterized by an appropriately high frequency in generating ultrasonic vibrations, as well as the proper geometric configuration for the cham-

ber in which the aerosol is formed. Inhalation is performed with the nebulizer through a face mask possessing a non-return valve which ensures a one-way air flow. During inhalation the patient is supine, as in intravenous adminstration of the isotope. However, the patient's position is not a determining factor in the quality of the scintigrams produced. Before the actual inhalation,the patient breathes through the mask several times to become accustomed to it. During the actual inhalation, which lasts about ten minutes, nine ml of colloid with an activity of approximately five mCi are introduced into the patient's lungs in aerosol form. The scintigraphic examination is performed immediately after inhalation with posteroanterior and anteroposterior scans. Lateral scans are also done in certain cases, particularly in situations with difficulties in localizing and defining the extent of ventilation impairment. In conditions of normal ventilation a scintigram obtained using inhalation presents a picture of the lungs with evenly distributed radioactivity (fig. 1).

In circumstances of abnormal ventilation the distribution of radioactivity in the scintigram is uneven; there may be an underaccumulation of the isotope, a complete absence, or an overaccumulation (fig. 2).

The first two situations can arise with bronchial asthma or bronchitis, for example, while excessive capture of the isotope can appear with the existence of emphysema (obstructive emphysema) foci.

Ventilatory lung scintigraphy is indicated in all cases where determination of local pulmonary ventilation is necessary (5).

An example is preoperative examinations for patients in whom impaired lung ventilation is indicated in spirographic examinations.

Scintigraphic examination can aid in judging the extent of a planned resection of lung tissue. With this method it is possible to reveal impaired functioning of the diaphragm after operations in the epigastrium. It also makes it possible to determine the extent and degree of advance of chronic obturative lung disease and to judge the effect of treatment on pulmonary ventilation and circulation. However, the inhalatory examination of lung ventilation has special significance in the diagnosis of pulmonary embolism. In this case it becomes crucial information alongside the evaluation of regional circulation and the evaluation of ventilation and local discrepancy between circulation and ventilation (4, 6, 10), (fig. 3 and 4).

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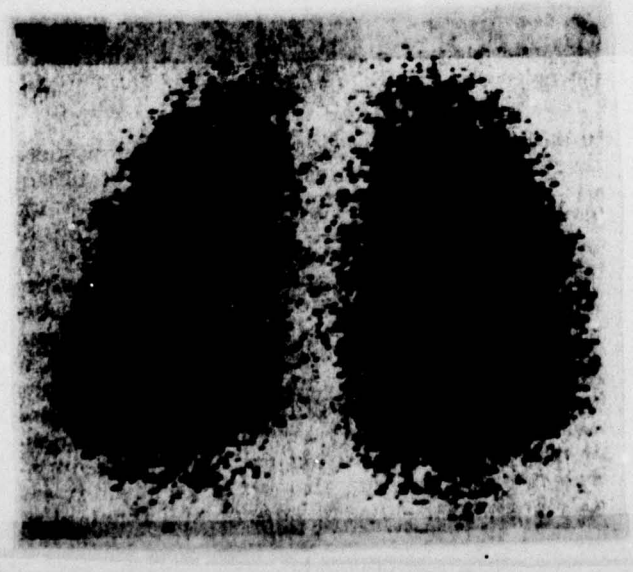

Fig. 1. Normal lung ventilation scintigram with posteroanterior view (PA).

Fig. 2. Ventilation scintigram (PA). Impairment of lung ventilation in patient with obstructive emphysema.

Fig. 3. Perfusion scintigram (PA). Complete absence of perfusion in lower lobe of left lung. Suspected embolism of lower branch of left pulmonary artery.

Fig. 4. Ventilation scintigram (PA) of same patient (see fig. 3). Normal ventilation of lungs, including lower part of left lung. Confirmed embolism of above-mentioned branch of pulmonary artery.

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